Tutorial Assignment 2: Ideal Gas and Electron Gas

Handwriting should be legible. Calculations should be explained. Units should be given. Numerical answers should be given to 4 significant figures.

1. A box of volume 24 dm^3 contains 1 mole of helium gas at 25 ^oC.

(i) Find the average kinetic energy, ε, of the helium atoms. [1]

(ii) Write down the formula for the total number of energy states below ε. Find this number. [1]

(iii) Explain what density of states is. Derive the formula. [1]

(iv) Write down the formula for the distribution of helium gas. Explain all symbols used. [1]

2. One mole of silver is at 1 K. Each atom supplies one conduction electron.

(i) Assuming that the electrons behave like an ideal gas, write down the expression for the average kinetic energy of the electrons. Hence find the heat capacity. [2]

(ii) At 1 K, the measured heat capacity is 0.5 mJ/K. Explain why it is different. [2]

(iii) With the help of a graph, estimate the energy range of the electrons that are excited above the Fermi energy at temperature T. [2]

(iv) In terms of the density of states at Fermi energy, $g(E_F)$, derive an expression for the number n of excited electrons. [2]

(v) Why is it reasonable to suppose that these electrons behave like the ideal gas? [2]

(vi) Assuming they do behave like the ideal gas, derive an expression for the heat capacity. [2]

(vii) Derive the formula for Fermi energy and find it. Explain your steps. (Molar volume of silver is 10.27 cm^3.) [2]

(viii) Calculate the heat capacity for silver at 1 K. Compare with the measured value and comment. [2]

CONSTANTS

Speed of light in vacuum	c	=	3.00×10^{8} ms^{-1}
Permeability of vacuum	μ_0	=	$4\pi \times 10^{-7}$ Hm^{-1}
		=	$4\pi \times 10^{-7}$ VsA^{-1}m^{-1}
Permittivity of vacuum	ε_0	=	8.85×10^{-12} Fm^{-1}
		=	8.85×10^{-12} AsV^{-1}m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck constant	h	=	6.63×10^{-34} Js
$h/2\pi =$	$\hbar$	=	1.05×10^{-34} Js
Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
Boltzmann constant	k_B	=	1.38×10^{-23} JK^{-1}
Gas constant	R	=	8.31 JK^{-1}mol^{-1}
Unified atomic mass constant	m_u	=	1.66×10^{-27} kg
		=	931.5 MeVc^{-2}
Electron mass	m_e	=	9.11×10^{-31} kg
Proton mass	m_p	=	1.67×10^{-27} kg
Gravitational constant	G	=	6.67×10^{-11} Nm^{2}kg^{-2}
Acceleration due to gravity	g	=	9.81 ms^{-2}
Bohr magneton	μ_B	=	9.27×10^{-24} JT^{-1}